

Population parameters of Blainville's and Cuvier's beaked whales

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LONG TERM GOALS

Beaked whales appear to be specifically sensitive to some acoustic sources, which can lead to mass strandings. The lack of knowledge about the population dynamics and reproductive parameters of these animals impedes the assessment of the population effects of stranding mortalities. The goal of this project is to continue a long-term photo-ID study started in the Canary Islands in 2003, in order to obtain a sufficient sample size for demographic modeling. This information will greatly augment the sparse knowledge of beaked whale population biology, facilitating the assessment of possible population effects of human impacts.

OBJECTIVES

The overall objectives of the project are the following:

1. To assess the spatial fidelity of beaked whales to the study area in the Canary Islands.
2. To estimate population size and analyze the dynamics of the local populations of Blainville's and Cuvier's beaked whales over a 12 year period.
3. To study medium and long term individual associations and individual site-fidelity.
4. To obtain life history parameters of Blainville's beaked whales from long-term photoID data

APPROACH

Determining when noise causes biologically significant effects requires making the transition from individual impacts, including mortalities, to population-wide effects. For this to be achieved it is essential to obtain data on vital rates and demographic parameters of the affected species (PCAD model, NRC 2005). Beaked whales (fam. Ziphiidae) are the most common taxa involved in mass strandings recorded in coincidence with naval exercises. However, because of their distribution in deep oceanic waters, they are usually difficult to study.

El Hierro (Canary Islands) holds resident populations of Blainville's and Cuvier's beaked whales in deep waters close to the shore (Aguilar de Soto 2006). This allows us to perform low-cost shore-based

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research on these species. The combined effort of observers from a coastal cliff and from a boat enables effective detection of groups of beaked whales occurring in the study area. The land and boat-based stations communicate by VHF radio and once a group is detected the boat approaches it to photograph the animals and obtain data on the composition and behavior of the group.

PhotoID studies performed by ULL since 2003, largely with NOPP/ONR funding, have produced one of the largest individual catalogs available for these species. This catalog is freely accessible on-line at www.cetabase.info and can be used by any entity or individual with beaked whale data, in the Canary Islands or elsewhere. Long-term monitoring provides an ideal opportunity to study social structure and demography in populations expected to be limited by natural variables such as habitat carrying capacity. Re-sightings of reproductive adults provide life-history data such as reproduction rates, essential to assess the recovery capacity of the species after mass mortalities.

Co-investigators on the project come from the University of La Laguna (N. Aguilar de Soto) and the University of Saint Andrews (P. Hammond). N. Aguilar directs and performs the scientific tasks, supervises researchers contracted to participate in the cruises and performs data analysis. P. Hammond is a qualified adviser, as a leader in the field of population abundance estimates and population dynamics of marine mammals, with an ample publication record in these subjects.

WORK COMPLETED

Field work and data collection

Since the signature of the agreement ONR-ULL in May 2012 we have performed seven seasonal photoID surveys off El Hierro, according to plan. Four of these cruises took place since the last report in September 2012, summing 56 days of fieldwork performed in October 2012 (11 days) and in February (14 days), May (19 days) and August (12 days) 2013. In total, 43 days (77%) had good conditions to work at sea and photoID was achieved in 36 days (8, 4, 15 and 9 respectively) of one or both resident ziphiid species in the waters of the island: Blainville's and Cuvier's beaked whales (*Mesoplodon densirostris* and *Ziphius cavirostris*).

In May 2013 three researchers from SMRU (University of St. Andrews, UK) collaborated in the field cruise. Their work was separately funded and provided ancillary data to this project and means to extend the duration of the spring photoID field cruise. The collaboration SMRU-ULL was aimed to tag beaked whales with suction-cup attached DTAGs. For this, both entities had the necessary permits and ethical approval. Two Blainville's beaked whales were tagged, a male and a female. Both whales travelled several miles offshore from the island during the tag deployment, while both were observed in the following days near the coast, showing that beaked whales with high affinity for El Hierro can still perform off-shore movements.

To study the connectivity and movements of the individual populations of beaked whales in the archipelago we obtained photos from whale-watching operators and researchers from all the other occidental Canary Islands: Tenerife, La Gomera and La Palma. There are not dedicated beaked whale research programs in these islands, where the whales are observed less frequently than off El Hierro. Because of this there is a limited database of photographs from these islands, summing 51 individual whales (43 Blainville's and 8 Cuvier's beaked whales). Of these, 25 Blainville's and 5 Cuvier's had sufficient body marks and were photographed with enough quality as to allow comparison with the photoID catalogue of El Hierro.

Meetings

The two IPs of the project met for data analysis in three occasions (March, April and June 2013) at the University of St. Andrews.

Online photoID catalogue (www.cetabase.info)

CETABASE (Figure 1) is a bilingual open-access virtual catalogue of beaked whale sightings and photoID data. It has analytical tools providing data summaries downloadable as csv spreadsheets and as text files ready to use in software *Mark* for population analysis. It is designed to allow data sharing of marine mammals often performing inter-boundary movements, while maintaining data ownership. Photograph pages are adapted to the photoID requirements of each species (e.g. 6 photos in the case of beaked whales). PhotoID data obtained during this project have been uploaded to CETABASE after each seasonal survey. The database holds now 201 Blainville's and 132 Cuvier's beaked whales individual pages.

Cetabase obtained 13,777 hits in the last month of September 2013, from 24 countries including 2700 hits from USA, and hits from Asian, African and European countries

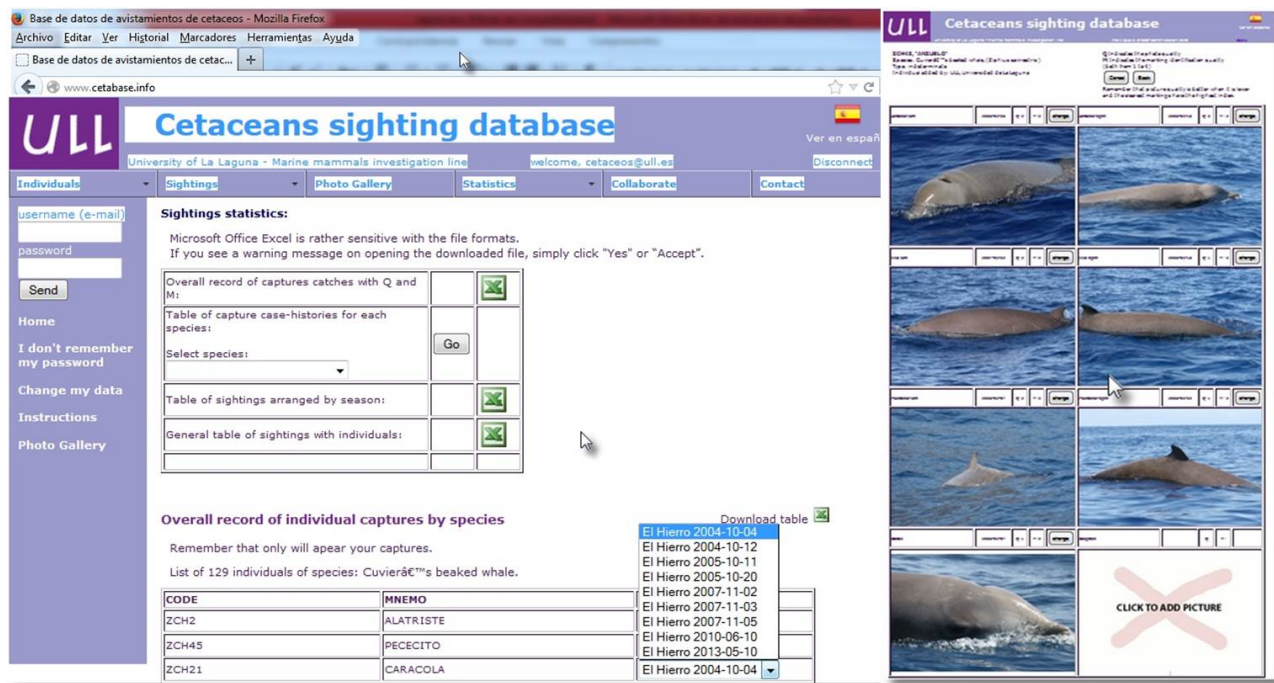


Figure 1. CETABASE (www.cetabase.info) is a bilingual on-line catalogue of beaked whales and other marine mammals. A welcome screen ensures acceptance of data use conditions and acknowledges funding sources. Photos and sighting data are open for viewing by the public while data processing queries are available to data providers.

To program Cetabase we used open software tools, building a database-intensive web application using /PHP and MySQL/ development technologies. The chosen web server has a Debian GNU/Linux OS to guarantee a perfect system stability in any situation. Cetabase is based on a logic database structure to store all the information from the sightings and the individual animals. This logic structure allows data to be linked according to defined data-fields and enables further expansion of the structure in an ordered manner. It also enables further expansion of the analytical capabilities of database, by allowing the programmer to design flexible queries to extract parts of the data and export results in user friendly formats, such as comma separated tables of jpeg images, as they are required by the users. The advantage of using a web application is that the server makes all the programmed analytical tasks once the data are entered in the database. Cetabase does not require any client software and thus it is possible to access Cetabase using just a PC with any operative system and any web navigator connected to internet. All data are centralized and a periodic back-up in the server guarantees the security of the information, while updates are accessible to users all over the world in real time.

RESULTS

Use of the area and site fidelity to El Hierro

Beaked whales were observed in the coastal waters of El Hierro in 83% of the 56 total days of effort performed from September 2012 to August 2013, and in 99% of the days of work at sea. This is consistent with the results of the previous years of study since 2003 and suggests that the population in El Hierro is not declining, as it has been observed in other areas (Moore & Barlow 2013). The total number of sightings of beaked whales from the land station was 649. Of these, 37% were not approached by the boat and could not be identified to species level, while 26% and 37% were Blainville's and Cuvier's beaked whales, respectively.

Photographic data have been analyzed excepting for the last cruise in August. A total number of 23 individual Blainville's and 38 Cuvier's beaked whales were photographed from September 2012 to May 2013. Of these, one and three whales of each species, respectively, had no recognizable marks and thus could be duplicated. Of the remaining adult animals, 12 Blainville's and 24 Cuvier's beaked whales had been previously observed in the island, while 5 Blainville's and 10 Cuvier's were new sightings. In addition we observed five calves of Blainville's beaked whales (of which 2 were re-sightings) and one new calf of Cuvier's beaked whale.

The marked adult population, i.e. animals with regular to very good photos and recognizable marks in the same area of the body, comprises 60 Blainville's and 59 Cuvier's beaked whales). Of these, 68 and 44 % of the individuals of each species, respectively, were observed only once during the last decade. Some of these whales may be transients, i.e. visited the area only once, while others may have been in the area and passed unnoticed, or may return to El Hierro after some years. The second option is supported by the long time-lags between consecutive sightings recorded for some animals, of up to four years, with a mean of 2 years. Based on this, if we don't consider the animals seen for first and only time in 2012 or 2013, 40% of the Blainville's and 63% of the Cuvier's beaked whales have been seen more than once. These animals form part of the population which can be considered as the core residents in El Hierro, with Blainville's beaked whales that have been observed from 2003 to 2013, in up to seven different years, and Cuvier's beaked whales observed up to 6 years in this period.

Inter-island movements

No matches were detected among the occidental Canary Islands for Blainville's nor Cuvier's beaked whales. However, there were several individuals observed repeatedly within one island, not only in El Hierro, but also in La Gomera and La Palma. This suggests that the populations have a strong fidelity for given islands, even if they may perform offshore movements.

Life history

Blainville's beaked whale

The analysis of the photoID data supports the following best estimates of life history parameters for the population in El Hierro: i) age of sexual maturity and first birth for females: ≈ 10 and 11 years, respectively; ii) inter-calf interval: ≈ 3 years and as low as two years in one case where the first calf was missing (death?); iii) weaning age: 2-3 years.

These parameters were obtained from a long-term series of photo-ID data of several females and mother calf-pairs. The history of recaptures of four females allowed us to obtain estimates of inter-calf interval and age of weaning, and one young female was monitored until first reproduction. Although the results have a limited sample size, they are consistent with the observations of Claridge (2013) on the Bahamas population of the same species. Figure 2 shows the sighting history of an individual female observed from young to first reproduction at 12 or 13 years of age. This female was first seen in 2003 as a juvenile aged at least two years, accompanied by her mother. One year later, she was re-

sighted in a group with another subadult, and separated from her mother. Between 2004 and 2011 there were five more sightings in groups with photo-identified adults, including three different males. In May 2013 she was seen with her first known calf aged at least one year. Assuming a gestation time of 12 months (following Mead *et al.* 1982, Walker & Hanson 1999), this female would have reached sexual maturity at age 10.

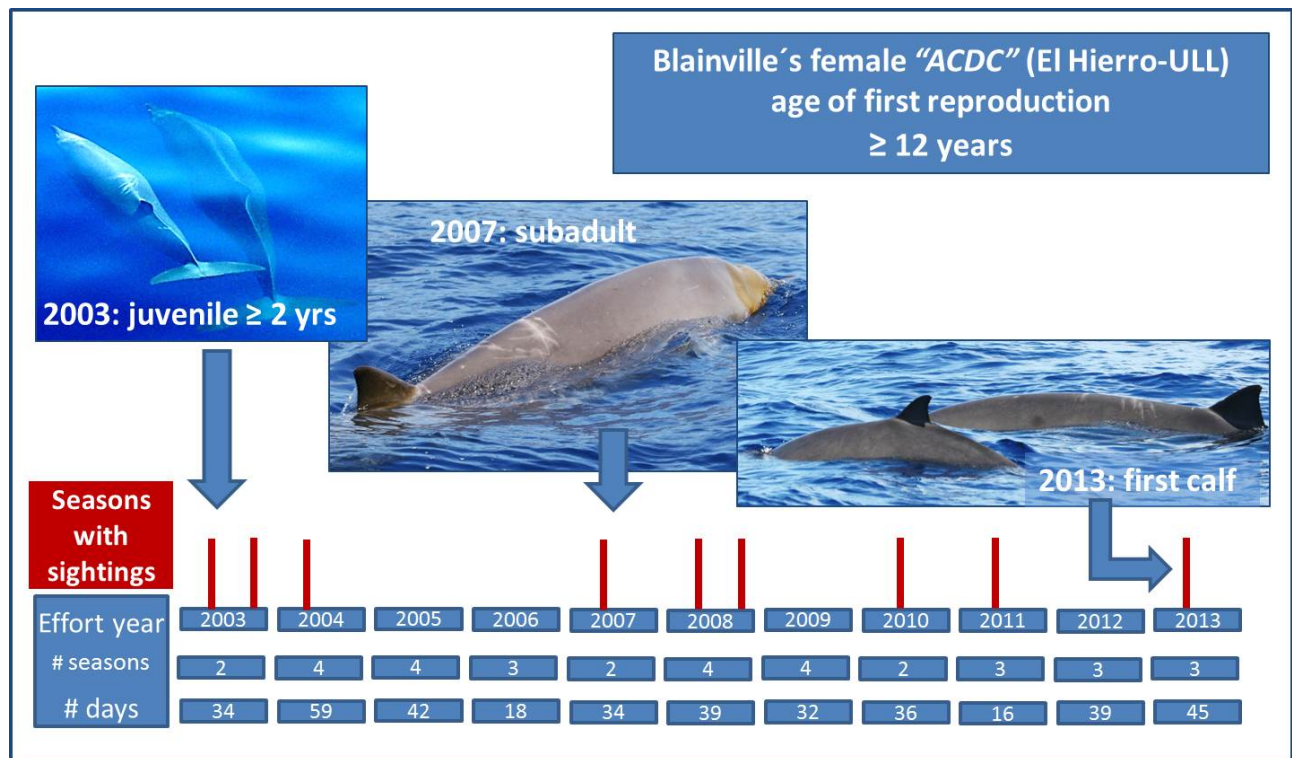


Figure 2. Age of first reproduction of a female Blainville's beaked whale obtained from a long-term monitoring of the population with photo-ID off the island of El Hierro

Strong associations among whales, often during yearly periods, confirm the visual observations of strong group coordination in whales diving and surfacing together. However, groups were observed to split and their members were then associated with other whales. A subadult female was observed in groups with two different males within one month, suggesting that females actively choose a harem to join or that subadult whales associate with harems without immediate reproductive activity. The data indicate that females breed with different males for consecutive calves, forming different harem groups with new individuals or in some cases with females previously associated.

Cuvier's beaked whales

Calves of Cuvier's beaked whales are rarer than calves of Blainville's in El Hierro and during the first years of study we did not record any calf. Only one female has been recorded with two young calves in El Hierro, in 2009 and 2013, resulting in an inter-calf interval of four years. This female was observed previously in 2008 with a male and no calves, and in 2003 with no association to young animals.

These data show the increasing value of long-term monitoring of beaked whale populations in order to understand their social structure and obtain accurate life-history parameters. These data are essential in order to improve models such as New *et al.* (2013) and feed transfer functions for PCAD models of population-level impact of acoustic sources.

IMPACTS/APPLICATIONS

National security

This work will provide important baseline data to assess the effects of naval activities, such as tactical sonar, on species protected under the US Marine Mammal Protection Act. To quantify the potential population effects of a given naval activity it is necessary to have knowledge about basic life history parameters of the species likely to be affected by the activity. These basic life history parameters include the size and dynamics of local populations, site fidelity and renewal rates (i.e. breeding rate, age of sexual maturation). Beaked whales are considered by the US Navy as species with enhanced sensitivity to intense acoustic sources, but there is still little or no information about the population dynamics of these species. This project is contributing data with direct applicability to perform modeling of potential population effects of human impacts.

Economic development

Economic development is often related to increasing noise levels in the ocean e.g. from ship traffic or mining activities. An improved understanding of the abundance, habitat use and population dynamics of marine mammals will help to plan human activities and help making economic growth more sustainable.

Quality of life

The project will contribute to the understanding of deep diving cetaceans, their use of the habitat, and their sensitivity to human interactions. The results will facilitate improved regional management with implications on ecosystem health.

Science education and communication

The project produces information that is made available to the general public in www.cetabase.info. Results from the project will base three scientific publications covering abundance estimates, social structure and life history parameters of the study species, including interpretation of results to contribute to PCAD models. Graduate and postgraduate students are involved in all facets of the work.

RELATED PROJECTS

Natacha Aguilar

- Sound use in the marine ecosystem (European Commission Marie Curie Fellowship) March 2010 – Feb 2013 (€297K). Current.
- Cetaceans, Oceanography and Biodiversity of Deep Waters in El Hierro and La Palma (Canary Islands). Spanish Ministry of Science and Education. Jan 2010, Dec 2013 (€253K). Current.
- Estimating beaked whale density from passive acoustic recordings. This proposal is submitted pursuant to ONR BAA 13-001. Code 32 - MMB. Monitoring and detection.
- CETAVIST. Cetacean and Seabird sighting net in the Canary Islands. Dec 2012-2014. ULL.
- Interactions between bottlenose dolphins and the deep-water artisanal fishery of El Hierro. May 2013-2014. ULL. Current.

Phil Hammond

- Harbour seal diet around Scotland: evidence for competition with grey seals (Scottish Government) Feb 2010 - Dec 2013 (£436K). Current.
- Distribution and abundance of cetaceans in the European Atlantic: preparation for SCANS-III survey (UK Department for Energy and Climate Change). Oct 2012 - Mar 2014 (£114). Current

- Bottlenose dolphins off the central east coast of Scotland (UK Department for Energy and Climate Change). Oct 2012 - Jan 2014 (£94K). Current
- Development of bycatch Limits for EU MSFD marine mammal indicators (UK Joint Nature Conservation Committee). Dec 2012 - Dec 2013 (£54K). Current

PUBLICATIONS

Results have been presented at no cost to the project in three meetings and conferences:

Aguilar de Soto, N. et al. 2013. From the Canary Islands success to the Mediterranean: Areas of Special Concern for Beaked Whales. 3rd Conference on the Effects of Noise on Marine Fauna. Budapest (Hungary) and 27th Conference of the European Cetacean Society, Setubal (Portugal)

Aguilar de Soto, N. (2012) Proposal of inclusion in Annex I CMS: Mediterranean subpopulation of Cuvier's beaked whale *Ziphius cavirostris*. Invited talk at the meeting of the Scientific Committee of ACCOBAMS (Mónaco)

Reyes, C. et al. (2012) CETABASE: a bilingual tool to enhance data sharing and public outreach on endangered species. 26th Conference of the European Cetacean Society (Ireland)

The data obtained during this project and the previous NOPP project has contributed to the following recent publications:

Barlow, J., Tyack, P., Johnson, M., Baird, R., Schorr, G., Andrews, R. and Aguilar de Soto, N. (2013). Detection probabilities for acoustic surveys of Cuvier's and Blainville's beaked whales. *Journal of the Acoustic Society of America*.

Arranz, P., Borchers, D. L., Aguilar Soto, N., Johnson, M. P., Cox, M. J. (In press). A new method to study inshore whale cue distribution from land-based observations. *Marine Mammal Science*.

Madsen, P., Aguilar de Soto, N., Arranz, P. and Johnson, M. (2013) Echolocation in Blainville's beaked whales (*Mesoplodon densirostris*). *Journal of Comparative Physiology A*. 199:451–469

The publication in a peer reviewed journal of the analysis of beaked whale population abundance in El Hierro has been delayed due to difficulties in the dataset. In spite of being one of the largest sets of photoID data of beaked whales, the sample size is still small and this impedes the application of several common statistical ways of mark recapture analysis. We have been testing different methods to overcome this challenge and the paper is now in preparation. A second paper analyzing the social structure of Blainville's beaked whales is also in preparation. Both are expected to be submitted in the first semester of 2014.

REFERENCES

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Claridge, D. (2013) Population ecology of Blainville's beaked whale (*Mesoplodon densirostris*). PhD. University of St. Andrews.

- Moore, J.E., Barlow, J.P. (2013) Declining abundance of beaked whales (Family Ziphiidae) in the California Current large marine ecosystem. PLoS ONE 8, e52770.
doi:10.1371/journal.pone.0052770
- National Research Council (2005) Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects. Committee on Characterizing Biologically Significant Marine Mammal Behavior. 142 pp.
- New, L.F., Moretti, D.J., Hooker, S.K., Costa, D.P., Simmons, S.E., 2013. Using Energetic Models to Investigate the Survival and Reproduction of Beaked Whales (family Ziphiidae). PLoS ONE 8, e68725.